

Muon-catalyzed fusion in ”warm-fusion”

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1. We would like once more to consider Ref.[1] in which a ”warm” fusion effect on $d - d$ nuclei was observed. The experiment was carried out in Broochyven National Laboratory (USA). A deuterated titanium plate TiD highly saturated with deuterium was bombarded by heavy water clusters $(D_2O)_N D^+$ (further we shall denote them as $(D_2O)_N$) with energy 300 keV.

As at is seen from Ref.[2] the results obtained are in a sharp contradiction to the standard concept of these processes. Attempts, made to explain the results of Refs.[2], [3] are unconvincing because they are aimed to reduce the experimental results to an old idea of fusion by macroparticles collision [4].

In this paper we represent a fusion model operating within a system $(D_2O)_N - TiD$ which enables one to explain the main peculiarities of the experiment [1] in detail not using the idea mentioned above [4].

2. Let us formulate the initial hypothesis which, from our point of view, is necessary to explain the experiment discussed :

g1. *The output N_{off} of a fusion reaction (counting rate) is proportional to the deuterium concentration C_D in the cluster $(D_2O)_N$ (the D atoms concentration in the target is constant).*

Hence, $N_{off} \sim C_D \sim N/V \sim N/R^3$, where N is the number of D atoms in the cluster $(D_2O)_N$; R is the average radius of the cluster. Thus

$$R \sim (N/N_{off})^{1/3}. \quad (1)$$

3. Hypothesis given above allows one to reproduce many peculiarities of the experimental data [1] but two significant problems are still not clear:

- why does a sharp change of fusion reaction behavior take place for $N \approx 110$?

- why does the number of deuterium "supplied" by clusters for the fusion reaction greatly decrease for $N > 500$ (vanishing practically) ?

Moreover, the most important problem - why does the fusion reaction occur at all when the deuterium atoms possess such a relatively low energy (0.5...12keV)? - remains unsolved.

We think that to solve these problems we need the following postulate:

in a molecule D_2O (in a cluster of heavy water $(D_2O)_N$) when its specific energy is of the order of 150eV one of the molecular bonds $O - D$ is changed into $O - D_\mu$ i.e. a molecule D_2O transforms into a muonic molecule.

4. Further considerations are sufficiently clear. First of all, we think that in the experiment [1], the process of μ -catalyzed nuclear fusion reaction was observed. Let us take into consideration that the initial hypothesis **g1** merely becomes one of the characteristics of the μ -catalyzed fusion (see for example Ref.[5]). In this case however the formula (1) is to be represented in the form

$$R \sim (N(1 - N_{off}B)/(kN_{off}))^{1/3}, \quad (2)$$

where k and B are constants. When the value of the output N_{off} of the fusion reaction is not so great, $N_{off}B \ll 1$. Ionization energy of a muonic atom D_μ is to be equal to $T_\mu = 206 T_o$, where T_o is the ionization energy of a hydrogen atom. Hence, $T_\mu = 2.8keV$. This is exactly the same energy that muonic atom D_μ has in a cluster at $N = 107$ (the cluster energy being equal to 300keV). Thus the processes, which occur in the experiment [1], can be described in the following way:

- for a small cluster size ($N = 25...110$) the specific energy of cluster muonic atoms D_μ is greater than their ionization energy; there appears a sufficiently high local concentration of nuclei d and free μ -mesons in the target after its collision with the cluster and "destroying" the latter; afterwards the μ -catalyzed fusion reaction develops according to the standard scheme;
- in large cluster ($N = 120...150$) the specific energy of a muonic atom D_μ is not sufficient to ionize it; as a result the cluster "supplies" in the target not charged particles (d and μ) but neutral muonic atoms D_μ ; probability of collisions between them is very small; hence, in this case, the fusion takes place mainly owing to collisions of muonic atoms D_μ with target nuclei d ; consequently the relative concentration C_D in comparison with light cluster sharply decreases.

Thus, we answered the first question of part 3 about causes of a threshold character of the fusion reaction at $N \approx 110$. To answer the second question we note that maximal cluster size N at which the cluster still has energy for dissociation of a muonic molecular axis D_2O (which moves so that its molecular axis $O - D$ and the movement direction make angle ϑ), can be calculated by the formula

$$N = T_N \cos^2 \vartheta / T_{dis}, \quad (3)$$

where T_N is the cluster energy and T_{dis} is the dissociation energy of a muonic molecule D_2O .

Unfortunately, the author doesn't know experimental value of the dissociation energy for a muonic molecule D_2O , but one can evaluate this energy judging from the following considerations. For the molecule H_2O the electron affinity is $0.9eV$. Hence, for the muon the electron affinity is to be equal to $185 eV$. Since, for dissociation of a muonic molecule D_2O through the canal $D_2O \longrightarrow D_\mu + DO$ the molecular bounding maintained by a muon is to be broken. Because of it the dissociation energy of a muonic molecule D_2O does differ from that of an ordinary molecule (*i.e.* $5eV$) by the $185eV$ value (the electron affinity for muon). Thus, $T_{dis} \approx 190eV$.

Then from (3) for $T = 300keV$ and $\vartheta = 0$ we obtain that $N = 1580$. If we take into account the fact that according to the classical theory of molecular bounds the angle between molecular axis $O - H$ in a water molecule is to be equal to 104° then for $T_o = 300keV$ and $\vartheta = 52^\circ$ we obtain the $N \approx 550$. However orientation of different molecules D_2O in a cluster toward the movement direction is likely to be rather random. Therefore in the range of N from 550 to 1580 the number of muonic molecules D_2O of a cluster which energy is sufficient for dissociation is smoothly vanishing.

In conclusion we note that the statement expressed as a postulate in the part 3 is a quality result of the quantum theory interpretation, which is developed by the author in his previous paper (Refs.[6]).

References

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